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THE RELATIONSHIP BETWEEN LAND USE AND SITE QUALITY IN RURAL WESTERN PUERTO RICO

by Lori A. Greenstein

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SITE QUALITY IN RURAL WESTERN PUERTO RICO

by

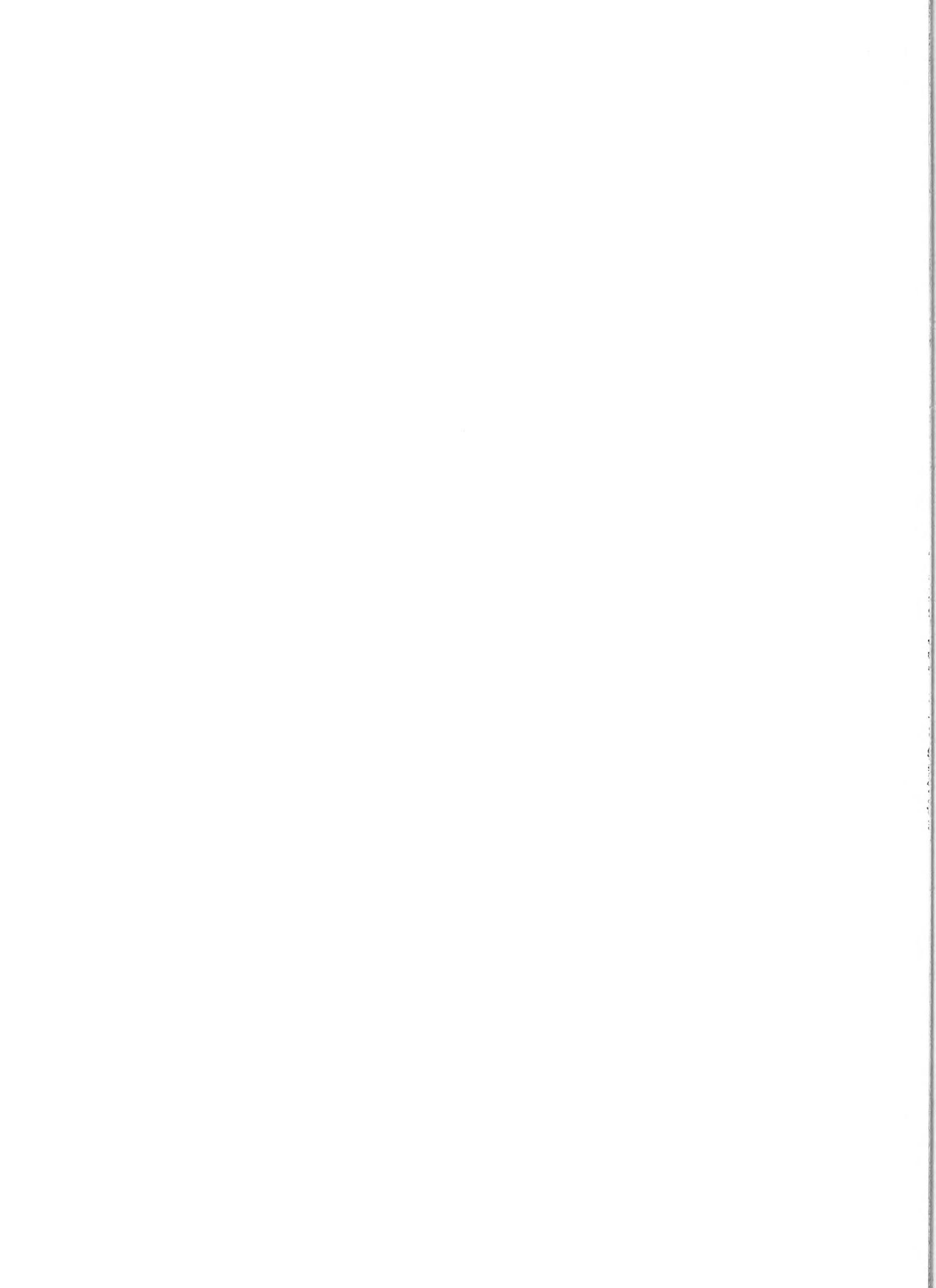
Lori A. Greenstein

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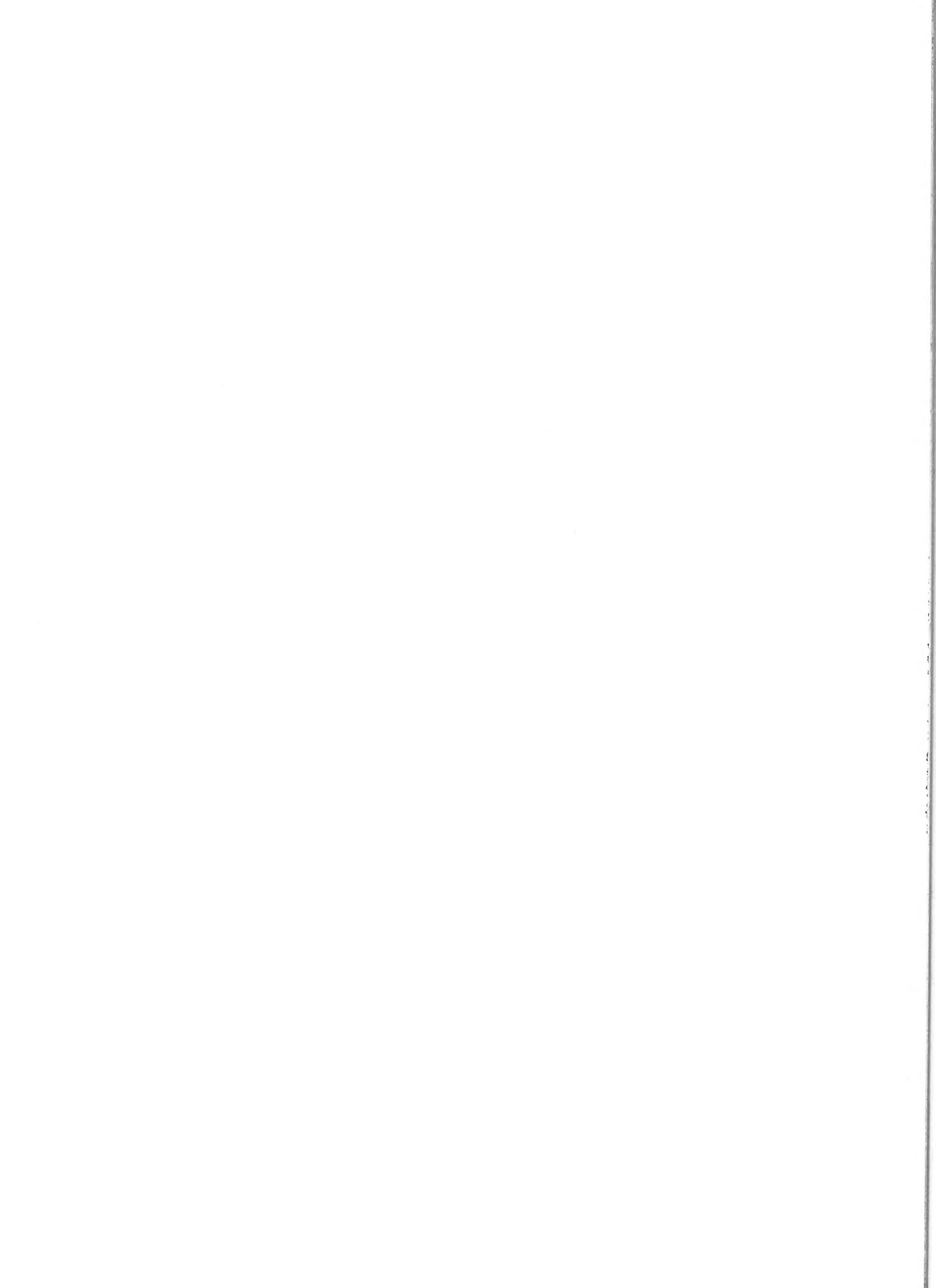
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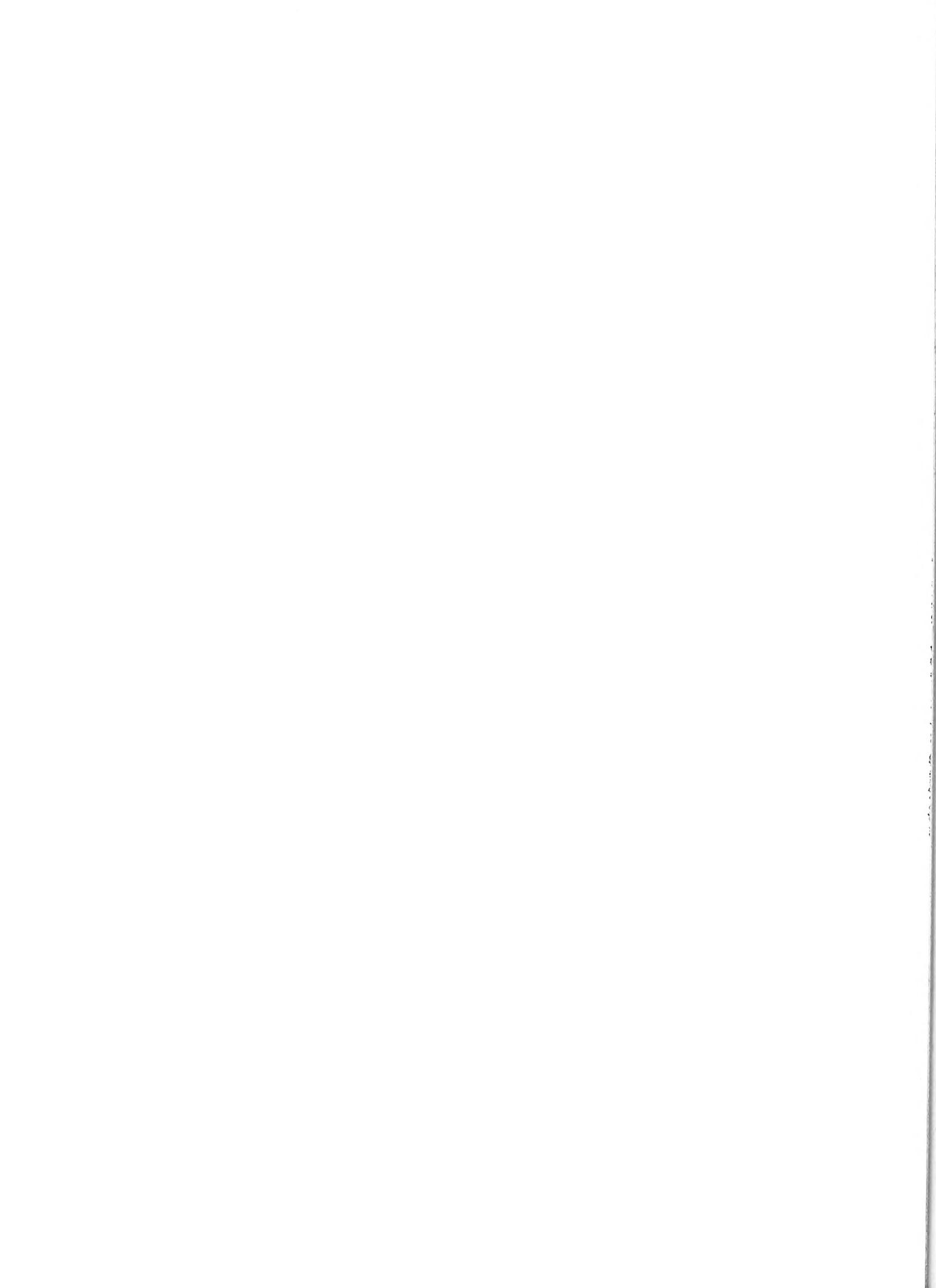
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ABSTRACT

The abandonment of agricultural land has been one aspect of the many recent socio-economic changes in Puerto Rico. The purpose of this study is to determine whether land abandonment is more common in areas of poor or marginal land or if it occurs in response to factors totally unrelated to land quality. For the purpose of determining the relationship between the land's potential capabilities and its present use, a site quality rating system was developed that establishes the potential productivity of the land at different locations. The optimum use for each site was determined by its site quality rating. This optimum use was then compared with the site's actual use to determine the present productivity level of the site relative to its potential capabilities. It was found that only 27% of the sites studied are currently being used in an optimum fashion. If the optimum land use pattern was realized: 1) only 4% of the land would be idle rather than the present 71%, 2) coffee production would occupy three times its present area, and 3) small subsistence type farms would be found on seven times their current area. Sugarcane is the only land use that presently occupies the majority of the land that is suited to it. In a country with Puerto Rico's current economic situation, gross underutilization of potentially productive land is a problem that deserves a great deal of attention.

INTRODUCTION

In the past few decades, Puerto Rico has experienced many changes in its economy and the character of its population. One aspect of these changes has been the abandonment of agricultural land. This study will explore the relationship between the present land use patterns and the physical quality of the land in a rural area of western Puerto Rico. The objective is to determine whether land abandonment is more common in areas of poor or marginal land, or if it occurs in response to factors totally unrelated to land quality. If the former is the case, perhaps there would be a possibility of reclaiming the land. If the latter is true, a valuable resource is being wasted in rural Puerto Rico.

Traditionally, Puerto Rico has had an agriculturally based economy. Following annexation with the United States in 1898, the island's population and industrialization began to grow at an increasing rate. In 1940, manufacturing contributed about one third as much as agriculture to Puerto Rico's net income (Pico, 1974). At that time, most of the island's industry processed domestic raw materials such as sugar, coffee, and tobacco. Under this arrangement, the large rural population worked as agricultural laborers and to provide raw materials for the industries.

In the 1930's, a drop in sugar prices put a severe strain on Puerto Rico's sugar based economy. The island's economic situation worsened until the late 1940's when an industrial development plan called "Operation Bootstrap" was started by Luis Muñoz Marin. Muñoz Marin, a political party leader and future governor of Puerto Rico, sought to boost the island's economy by expanding and strengthening the industrial base and, through "Operation Bootstrap," attracted a wide variety of industries to the island. Agricultural development was deemphasized.

Although Puerto Rico has limited space and few raw materials, factors such as the abundance of "cheap" labor, its location between North and South America, a ten to twenty-five year tax moratorium, and exemption from federal income tax all together made Puerto Rico a very attractive location for United States industries (Lieber, 1980). This resulted in a major shift in both the geographical distribution and the occupations of the population. Formerly rural farm laborers and small landowners were attracted to the urban areas to find higher paying, less demanding, year-round employment in the new industries. In addition to the effect of population shifts within the island, the rural areas lost population during the 1950's and early 1960's when Puerto Rico experienced heavy out-migration to the United States (Monk and Alexander, 1979).

Prior to industrialization, labor intensive coffee plantations occupied the majority of the land in the western hill region of Puerto Rico. The population

shifts described above resulted in the abandonment of much of this agricultural land. Many farms were abandoned when their owners found factory work and the farmers that remained could not find the low-cost labor that was necessary to make a profit as they were able to in the past.

Land abandonment continued through the 1940's and the 1950's until, by 1965, a complete reversal had occurred between manufacturing and agriculture in their relationship to the island's net income. As mentioned earlier, in 1940 agriculture contributed three times as much as manufacturing to Puerto Rico's net income. In 1965, manufacturing accounted for three times the amount of agriculture (Pico, 1974). This trend continues today at a geometrically increasing rate; in 1975, manufacturing contributed ten times the net income of agriculture.

The introduction of the food stamp program in 1975 further reduced agriculture's viability as an occupation. Cupones (food stamps) are awarded to 53% of the population; the most widespread program stateside is 12% in Mississippi (Lieber, 1980). In addition to being widespread, the food stamp program in Puerto Rico is very poorly regulated; the stamps can be used to purchase anything, not just food. Due to the low rate of pay for agricultural work, rural people who may have previously worked as farm laborers now have the option of remaining unemployed and living on cupones.

Yet another factor contributing to the decline of agriculture in Puerto Rico is the inheritance practice called successión. When a landowner dies, his property is divided up equally among his heirs. As in other developing, predominantly Catholic countries, large families are quite common. This leaves each heir with a section of land that is too small to farm economically. The usual result is that they will either divide up the land further to be sold for residential development or they will allow it to remain idle.

The end result of the direct and indirect effects of the factors described above is the continuing decline of agriculture in Puerto Rico. This decline has left the formerly productive western hill region a mosaic of abandoned, idle land dotted with small farms. In addition, the average age of the remaining farmers (late fifties and early sixties) indicates that these last few small farms may soon disappear (Alexander, 1980). Puerto Rico's limited space, severely limited mineral resources, and increasing dependence on expensive imported food warrant a close examination of the present situation and careful planning for future changes.

As a consequence of the continuing nature of rural change, Puerto Rico is an excellent location to study the process and the effects of modernization. Detailed geographical studies documented in the 1940's and early 1950's (Roberts, 1942 and Imus, 1951) allow accurate comparisons between past and present conditions. Changes occurring in the rural landscape of western Puerto Rico between 1950 and 1977 have been clearly identified through field work and comparison with detailed land use maps prepared by Northwestern University and the University of Puerto Rico in 1950 and 1951 (Monk and Alexander, 1979). Two barrios (small civil divisions) located in the hinterland of Mayaguez (Figure 1), that were included in studies by Monk and Alexander (1976 and 1979) are the particular setting for this study. Leguisamo is an area of volcanic uplands close to Mayaguez. Ovejas, slightly further from town, consists of volcanic uplands in its southern portion and the flood plain of the Rio Grande de Añasco in the north (Gierbolini, 1975).

The particular purpose of this study is to investigate the physical properties of selected sites in Leguisamo and Ovejas in order to determine what relationship exists between the land's potential capabilities and its present use. Based upon field data, a site quality rating system was developed that establishes the potential productivity of the land at different locations. The study sites were then grouped into present land use categories. With the data in this form, it was the

STUDY AREA

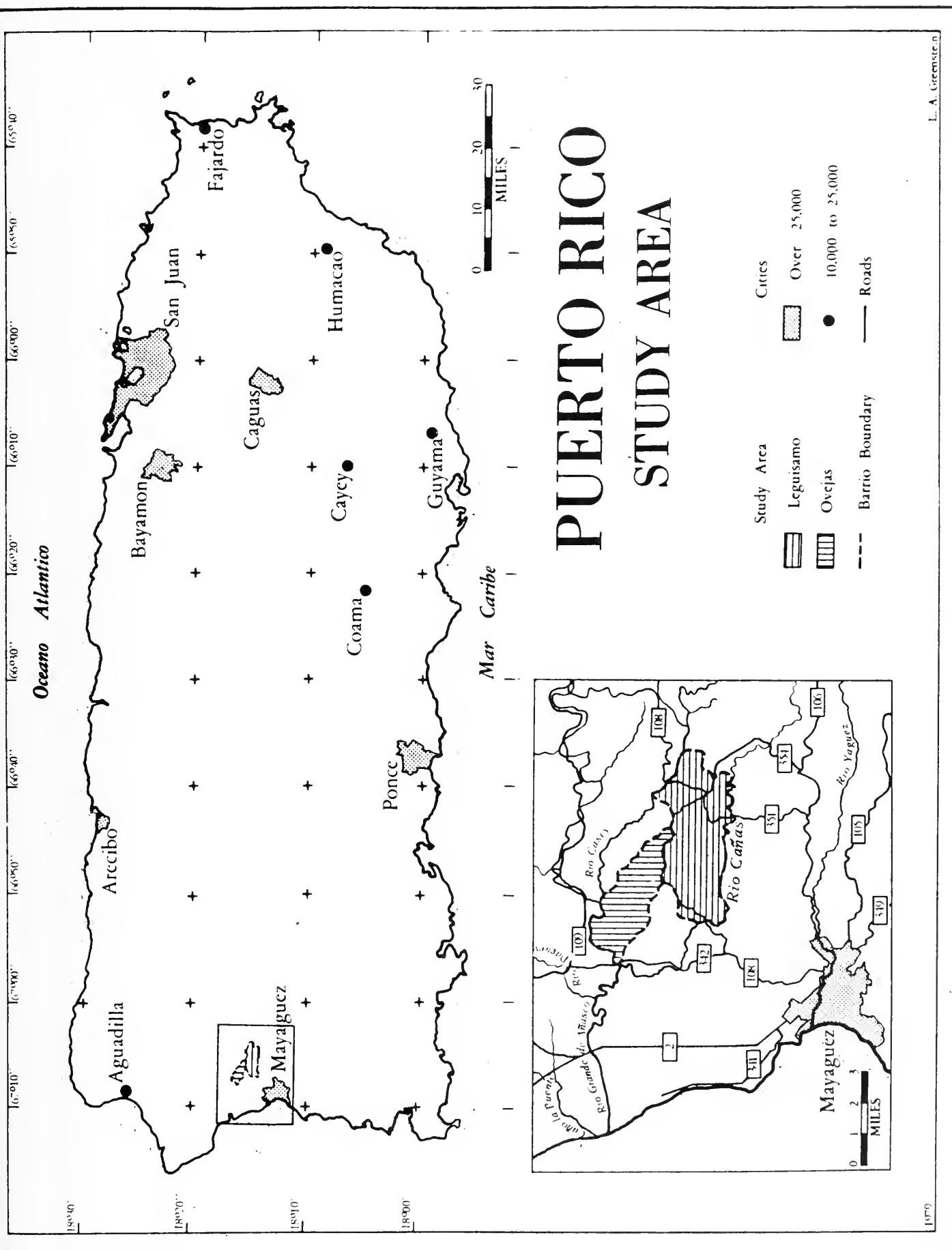


FIGURE 1

possible to examine the range of site quality ratings associated with each land use category. By determining the optimum quality range for each of the land use categories, the optimum use for each site could then be inferred. This optimum use, when compared to that location's actual use, indicates whether the land is being operated at its potential or at some point above or below that productivity level.

METHODOLOGY

Field Methods

In order to establish the relationship between land use and site quality, specific sites were identified, located in the field, and categorized according to land use and site quality. At each sample point, observations were recorded including land use, evidence of past land use, and use of the surrounding area in order to classify the site into a land use category. For use in rating site quality, the vegetation type, density of ground cover, percent canopy cover, and fall height; presence of organic litter; humus in the soil; and soil color were also recorded at each location.

A systematic sampling method was employed with sample points located every 2000 feet (approximately 610 meters) in a grid pattern on 1:20,000 United States Geological Survey (USGS) topographic maps (USGS, 1964 and USGS, 1966). Maximization of the number of points in each barrio determined the placement of the grid. Each sample point was located with reasonable accuracy (estimated to be within a radius of fifty feet, approximately fifteen meters) in the field with the use of the topographic maps and a compass.

At least one soil sample of each soil type was collected; if the same type soil was found at a sample point in both barrios, a sample of each was taken. These samples were taken from a depth of six to eight inches, air dried, and returned to the United States in double-sealed bags for chemical analysis. The

laboratory analysis, performed by A & L Great Lakes Agricultural Laboratories, was used as part of the quality rating process.

Computation of the Universal Soil Loss Equation

An important part of rating a site's quality in terms of its potential productivity is the site's susceptibility to erosion (Wischmeier, 1976a). This is particularly true in this study area where steep slopes and abundant rainfall are characteristic. The Universal Soil Loss Equation (USLE) was the basis for an erosion index to be used as part of the site quality rating.

The USLE, a method of calculating field soil loss, was developed with data from controlled studies on runoff and soil loss by the Runoff and Soil Loss Data Center of Agricultural Research Service at Purdue University. The Soil Conservation Service (SCS) used the equation in the eastern United States for years as an erosion prediction tool to aid in planning conservation practices (SCS, 1978). Although the equation was developed to be "universal," it is not, as yet, adequately tested for use in areas outside of the eastern United States (Wischmeier, 1976b). It is, however, the best available tool for the prediction of soil loss in Puerto Rico. SCS has printed a USLE Technical Note for the Caribbean area (SCS, 1978) that proved an indispensable aid in adjusting the equation for use in this study.

The equation is as follows:

$$A = R K L S C P$$

A = total soil loss in tons/acre/year

R = rainfall erosivity factor

K = soil erodibility factor

L = slope length factor

S = slope gradient factor

C = cropping or vegetation factor

P = erosion control practice factor

The rainfall (R) and soil (K) factors for this study were obtained from previously produced SCS maps and tables. The two slope factors (L and S) were computed from the 1:20,000 USGS topographic maps (Appendix A).

The vegetation (C) and erosion control practice (P) factors were excluded from the computation. When these factors are included, the result reflects the site's immediate use and the seasonal variation of the vegetation present. Without C and P, the result is the potential soil loss from the site if it were a tilled, continuously fallow field. By excluding these factors, a more meaningful comparison between the inherent potential for erosion at different locations was possible.

Site Quality Rating System

Using information from observations in the field, laboratory analysis of the soils, the results of the USLE, and various other sources, the physical characteristics of each site may be evaluated and classified according to quality in order to examine the relationship between the overall site quality and the land's present use. The rating system needs to include both the assumed characteristics by virtue of soil type and the actual conditions observed through field work. I was not able to find an existing rating system that seemed appropriate for the purpose of this study. Consequently a system was developed for this study using information from existing literature on soils in western Puerto Rico and the author's experience with soils, soil erosion, and the region. The rating system appears to be completely quantitative; however, the reader is cautioned that subjectivity played a role in the selection of the factors, the relative importance of each one, and the scales used.

The factors used to determine the site quality rating (SQR) of a site are as follows: erosion potential, slope, soil type, and chemical fertility (Appendix B). The possible values for each factor are divided into a number of

intervals. Each interval is given a value rating. The relative weight of each factor in the SQR is determined by its number of intervals which, in turn, determines the size of the largest value rating. The cut-off points between intervals are placed at natural breaks in the data and/or logical points given the effects of that particular factor.

The erosion potential of each site as determined by the USLE is represented by the erosion index (EI). This factor is given considerable weight in the SQR due to its importance in the region and the fact that this index represents the soil's inherent potential for erosion which may indicate the effects of past erosion, the occurrence of erosion today, and the potential for future soil loss. In order to give the EI the desired weight in the equation, it is divided into five intervals with a rating of 5 possible. The scale used for the EI is more geometric than arithmetic because, in my judgement, this more accurately represents the harm done to the site's potential productivity by the various levels of potential soil loss.

Slope angle is represented in the EI as it affects the rate of erosion. However, slope is introduced again as the slope index (SI) because of its role as a limiting factor for agricultural practices. Some land in the study area is level enough that mechanized farming methods are an option. Other areas preclude mechanization due to slope but are easily worked if laborers are available; while other parts of the region are so steep that it would be extremely difficult for farm laborers to work the land. The SI is divided into three intervals representing land that is acceptable for mechanization, too steep for mechanization but acceptable for laborers, and too steep to be easily worked by laborers.

Eleven different soil types representing seven soil series are represented in the samples taken for this study. Appendix C provides a brief description of these soils and lists the land uses encountered on each. The SCS Soil Survey of

Mayaguez Area of Western Puerto Rico (Gierbolini, 1975) divides the soil types of the region into eight capability ratings. Their system is based on a number of predominantly physical factors including average depth of profile, drainage conditions, permeability, available water capacity, workability, and chemical fertility. Appendix D describes the SCS capability units and lists the soil types in the study area that are found in each. The SQR soil type index (STI) is based on these capability units to account for the physical variation between soil types. So as not to give the STI inordinate weight in the SQR, the six capability units in which study sites occur have been grouped into three intervals.

Although the average chemical fertility of each soil type is taken into account as part of the STI, the actual chemical characteristics of the soil samples taken at representative sites in the study area merit an additional index. The relative importance of a soil's chemical fertility is not adequately represented in the STI as the SCS capability units are based primarily on the physical properties of the various soil types. The chemical fertility index (CFI) is based on a laboratory analysis of soil samples taken from between six to eight inches below the surface. As was previously mentioned, only one soil sample from each soil type represented in each barrio was taken for analysis because it was too expensive to test samples from all sites. The chemical characteristics of the tested sample are used as a basis for the CFI for all soils of that type in that barrio.

The CFI consists of three separate characteristics: cation exchange capacity, estimated nitrogen release, and pH, all of which are important in determining a soil's potential productivity. Each of these three characteristics is rated separately.

The first section of the CFI, cation exchange capacity (CEC), is a measure of a soil's ability to store and supply nutrients (exchangeable bases).

Therefore, a low CEC restricts the plant's ability to use the nutrients that may be present in the soil. CEC generally remains a fixed value for a particular soil, changes being observed only over time intervals of 20 to 50 years or as a result of heavy erosion or deposition (Ankerman and Large, n.d.). Due to the nature and age of the clays in the region, the soils tend to have low CEC's (Brady, 1974); though significantly different CEC's were observed. The laboratory analysis rates nutrients as being present in high, medium, or low percentages relative to that soil's CEC. Without an adequate supply of nutrients, a high CEC does little to increase a soil's chemical fertility. Potassium, magnesium, and calcium are three nutrients that play a major role in a soil's ability to produce crops. Therefore, the CEC rating for each site is based on four characteristics; the actual CEC and the relative percentages of potassium, magnesium, and calcium present (Appendix B).

The second characteristic represented in the CFI is the estimated nitrogen release (ENR). Nitrogen is used in large quantities by most plants. Although it is abundant in the air, it is not in a form that is available to plants. Estimated nitrogen release is a measure of the nitrogen that is available to plants in a soil. As organic matter is the agent by which nitrogen is made available, this rating also represents the soil's percent organic matter (Ankerman and Large, n.d.).

The final factor included in the CFI is the soil's pH. All the soils sampled were found to be quite acidic as is common with soils in the humid tropics. Beyond a certain acidity (pH of 5.2), pH is considered to be a severe limiting factor for potential productivity (Ankerman and Large, n.d.). The pH ratings given to the soils for the CFI are based on this principle.

The three indexes discussed above (CEC, ENR, and pH) together comprise the CFI. When added to the site's EI, SI, and STI; the sum is the Site Quality

Rating* (Appendix E). Those sites with the higher SQR's are capable of higher productivity and supporting more demanding crops than those sites with the lower SQR's. As previously mentioned, subjective decisions contributed to each step of this rating system; the scales are not entirely based on quantitative measurements. However, the system was designed specifically for the area of this study and it appears to provide a realistic appraisal of local land quality. No claim is made that it could be applied in other regions and produce satisfactory results.

LAND USE

Discussion of Past Land Use

It is evident from my field observations that most (if not all) of the land in the study area had been cleared at some time or other and used for agricultural production. A large percentage of the land, predominantly in the uplands, was devoted to coffee. Coffee trees grow well on the steep slopes and due to the fact that shade is desirable to increase the quality of the product, "two-story" farming was often practiced. Using this method, the productivity of an individual plot of land can be increased by growing coffee in the shade of tall fruit trees. As mechanization is not possible on the steep slopes of the upland areas; all planting, maintenance, and harvesting had to be done by hand. On the smaller landholdings (fincas), the farmer and his family were responsible for most of the labor, perhaps employing a few additional hands at harvest time. The large coffee plantations (haciendas) employed full-time laborers who lived with their families on the hacienda.

Another large percentage of the land, predominantly in the floodplains and lowland areas, was used to grow sugarcane. Sugarcane grows well and is easily worked in large, fairly level fields. Although some mechanization is

* An example of an SQR computation for Site #1 is shown in Appendix F.

possible in certain areas where sugarcane is grown, the use of farm machinery began quite recently. Previous to that, large amounts of labor were needed to work the fields. All things being equal, working in a sugarcane field is a less desirable occupation than labor on a coffee plantation. The sugarcane is grown on the steamy lowlands with no protection from the sun rather than the shady coffee fields in the cool uplands.

The rest of the land, that which was not occupied by either coffee or sugarcane, was most likely used for subsistence farming. Traditionally, rural people grew most of their own food or traded amongst themselves. The rural stores provided liquor and recreation rather than food supplies and travel to town was predominantly for obtaining durable goods (Monk and Alexander, 1979). These gardens produced a wide variety of crops for consumption and most likely, a small amount of coffee or some other surplus crop to generate capital for the family.

Present Land Use

The land uses encountered in the field can be conveniently grouped into six classifications: idle land, recently abandoned (referred to as idle (A)), garden, coffee production, sugarcane production, and other. Of the 45 sites studied, the following percentages were found in each of the land use categories.

TABLE 1
PRESENT LAND USE

| Land Use | Percent |
|-----------|---------|
| Idle | 31 |
| Idle (A) | 36 |
| Garden | 7 |
| Coffee | 11 |
| Sugarcane | 11 |
| Other | 4 |

The sites included in idle land are those areas of either secondary forest or open field that showed only slight signs of past use. The secondary character of the forest and scattered but abandoned fruit trees provide evidence that these sites were once cultivated; they may be considered abandoned land. Idle (A) sites are those that are not presently in use but have evidence of recent use. Types of evidence were the presence of scattered, barren coffee trees (when not maintained, the trees virtually cease to produce beans), partially eroded narrow cane roads used for the harvest wagons, partially eroded terracing, presence of a relatively large number of fruit trees, etc. It is estimated that land that was abandoned less than 20 to 30 years ago would show these signs of past use. All together, the abandoned land (idle and idle (A)) represents approximately two-thirds of the sites sampled. Based upon field observation, I believe this sample to be representative of rural western Puerto Rico. If so, two-thirds of the formerly cultivated land is now standing idle.

The land comprising the garden category of land use is assumed to be the modern-day counterpart of subsistence agriculture. The sites were characterized by relatively small plots of cultivated land containing many different types of ground crops, fruit trees, and a few coffee trees. These small plots were very well tended (one was terraced) and appeared to be very productive. It is most likely that these gardens serve to augment the families' incomes and reduce their food costs rather than as a true means of subsistence. The 7% of the total represented by the garden category is certainly far less than was represented by subsistence agriculture in the past. This observation indicates that subsistence, as a way of life, has virtually disappeared from this region of Puerto Rico.

The land use category of coffee production represents only 11% of the total. This too is certainly only a fraction of its former percentage. These sites ranged from being planted strictly in coffee to displaying a diverse two-story method; from being poorly tended with low productivity to appearing carefully

manicured with branches weighted heavily with coffee beans. All the observed areas planted in coffee are rather modestly sized, the large haciendas are no longer operating. Nearly all the coffee fields were shaded by coconut, banana, or plantain trees. All the coffee production observed in the field took place in the steep upland areas.

Most of the sites in the sugarcane category are found on the Rio Grande de Añasco floodplain. These areas resemble midwestern United States agriculture with large fields of row crops on nearly level ground. The alluvial soils that the sugarcane grows in are dark brown and more fertile than the brick red soils found in the uplands.

The remaining category, other, consists of two sites that did not fit into any of the land use categories. One site is located in a brand new urbanización (planned residential development). The other site is adjacent to a stream inside a rock quarry. These soils had been greatly disturbed by earth-moving equipment.

RELATIONSHIP BETWEEN LAND USE AND SITE QUALITY

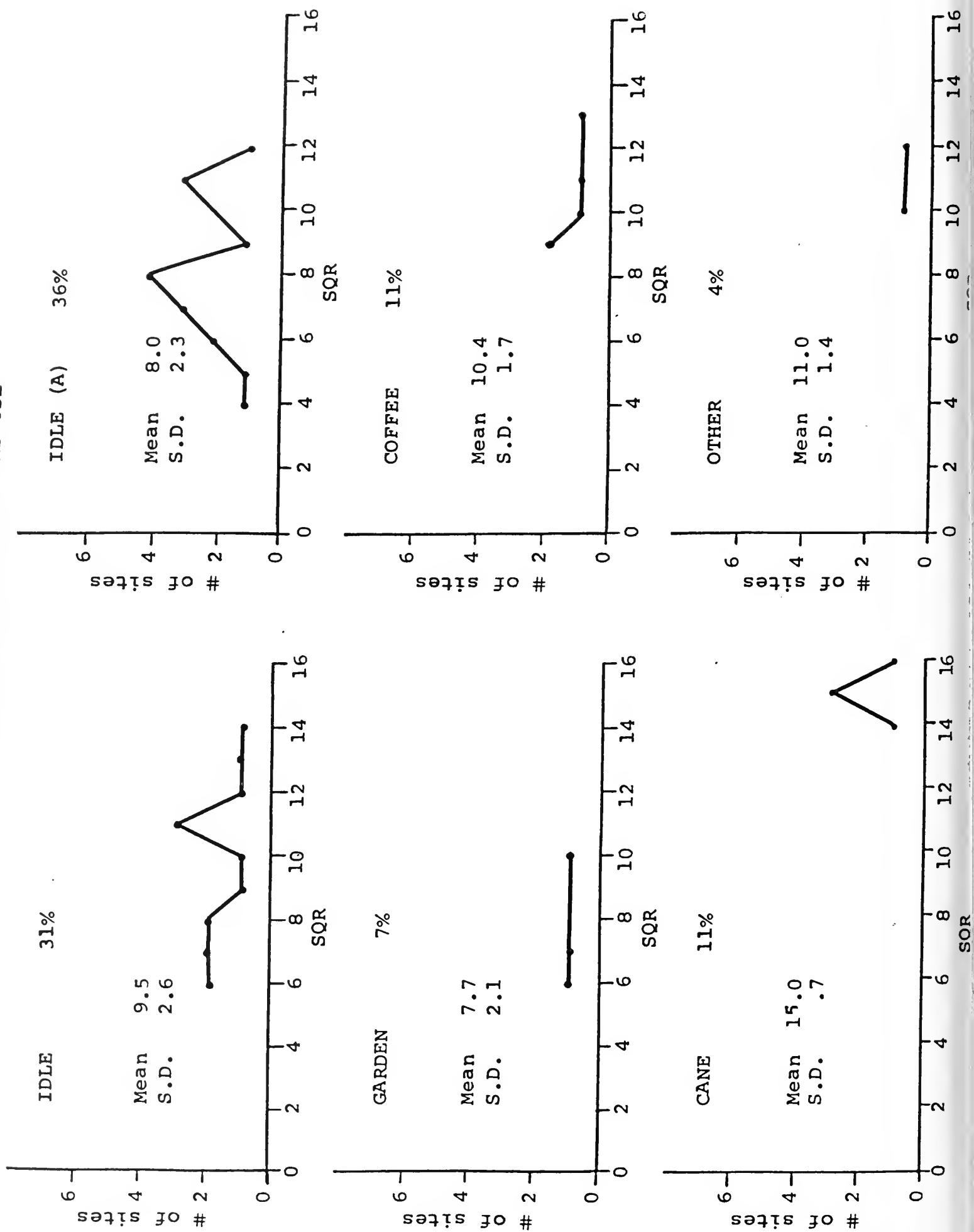
Once site quality ratings and land use categories have been assigned to all sites, it is possible to examine the relationship between the relative quality of the sites and the present land use. Figure 2 illustrates the site quality ratings found in each land use category. Table 2 is a summary of the range and mean SQR's for each land use category.

TABLE 2
SQR MEAN AND RANGE BY LAND USE

| Use | SQR Mean | SQR Range |
|-----------|----------|-----------|
| Idle | 9.5 | 6 - 14 |
| Idle (A) | 8.0 | 4 - 12 |
| Garden | 7.7 | 6 - 10 |
| Coffee | 10.4 | 9 - 13 |
| Sugarcane | 15.0 | 14 - 16 |
| Other | 11.0 | 10 - 12 |

FIGURE 2

SITE QUALITY RATINGS BY LAND USE



The widest ranges are covered by the two categories of idle land. The lowest mean SQR is found in the garden category and the highest is found in sugarcane areas. Gardens are located on sites with lower ratings than either coffee or sugarcane.

It can be inferred from this table that potentially productive land is idle at the present time. SQR's of 4 and 5 are found only in the recently abandoned category. This low site capability is assumed to be the reason for abandonment. Ninety-three percent of the idle sites, however, have SQR's in the range of 6 to 14. Other sites found in this SQR range are productive in other parts of the barrios. In these cases, abandonment may have been the result of factors other than the land's physical characteristics.

Examination of Table 2, Appendix E, and field observations enabled determination of the range of SQR values required for particular land uses. Table 3 shows the optimum use for land of different SQR ranges. Optimum use is defined here as the most economically productive use possible given the site's limitations. These ranges should be taken as approximate.

TABLE 3
OPTIMUM USE BY SQR RANGE

| SQR Range | % of Sites | Optimum Use |
|-----------|------------|--------------------|
| 14 - 16 | 13 | Sugarcane |
| 10 - 13 | 36 | Coffee |
| 6 - 9 | 47 | Garden |
| 4 - 5 | 4 | Idle or Pasture |

Sugarcane requires the highest SQR in order to be economically feasible. Coffee is successfully produced on land with a lower SQR and productive gardens may be found on marginal land. The lower limit of these ranges is the lowest

SQR on which the optimum use was observed to be productive in the field. To explain, notice from Figure 2 that two sites with an SQR of 9 were found to be planted in coffee. However, it was observed in the field that those sites were relatively unproductive, the trees were quite small with few beans on the branches. Therefore, an SQR of 9 was not included in the range for coffee production; it became the upper limit for the next less demanding land use.

From Tables 1 and 3, it is possible to compare the percent of each land use that is possible given the SQR ranges observed and the actual percent of each land use. Table 4 compares the percent of the study area currently occupied by each land use category with the percent of the land that would be occupied by each land use if the optimum land use pattern were realized.

TABLE 4
COMPARISON OF OBSERVED AND OPTIMUM LAND USES

| Use | % Observed | Optimum % |
|-----------|------------------------|-----------|
| Sugarcane | 11 | 13 |
| Coffee | 11 | 36 |
| Garden | 7 | 47 |
| Idle | 71 (includes Other) | 4 |

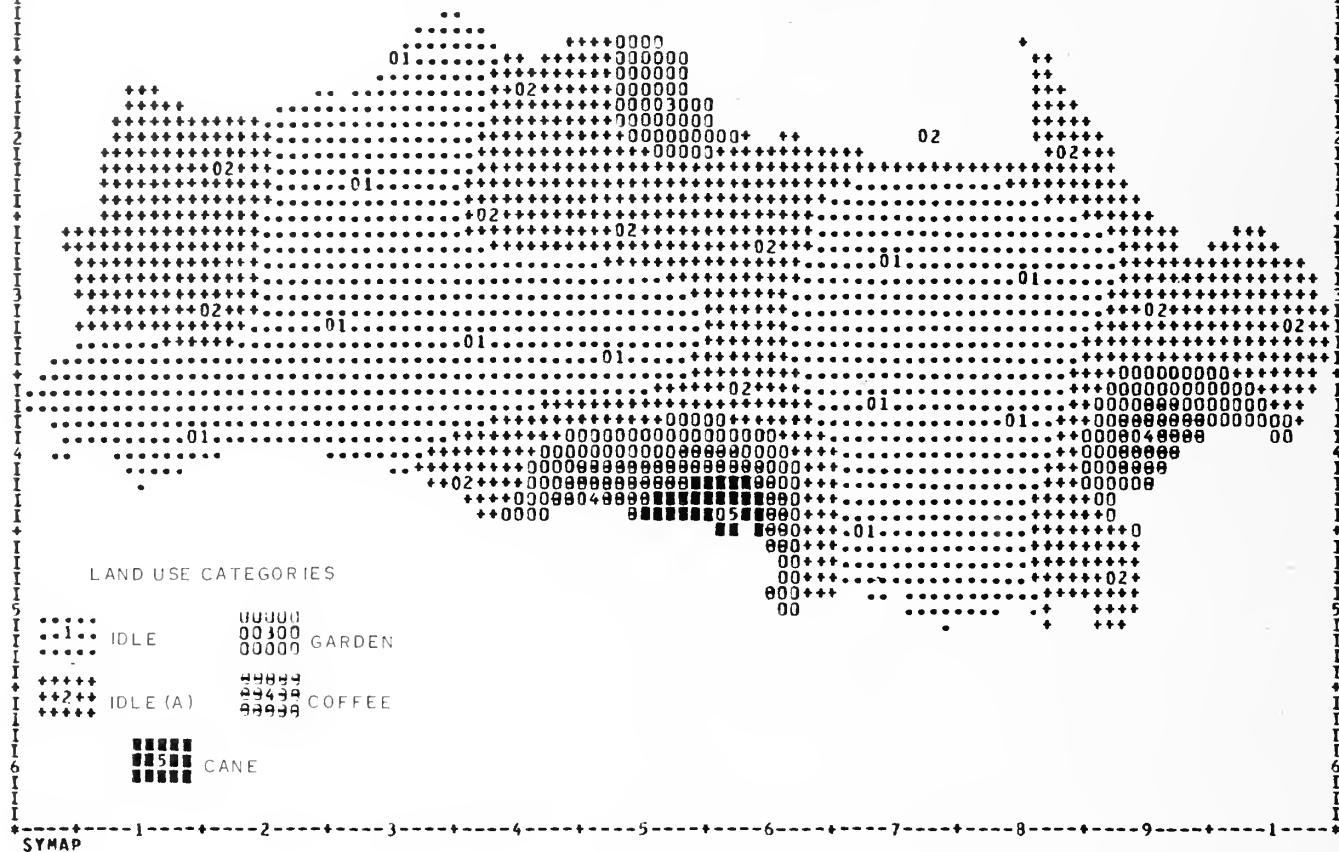
Sugarcane is the only land use that presently occupies the majority of the land that is suited to it. Coffee production could be increased at least three times its present area before it would begin to occupy marginal land. Almost seven times more area could be used as gardens allowing many more families to grow some of their own food and most likely produce a cash crop as well. Only 4% of the land sampled in the two barrios has a SQR low enough to justify its remaining idle as compared to the 71% that presently is idle.

The upper maps in Figures 3 and 4 illustrate the present land use patterns in Leguisamo and Ovejas respectively. Sugarcane, the most demanding of the land use categories, has the highest value, 5. Coffee, the next most demanding category has a value of 4 and gardens are represented by 3. Idle and recently abandoned land are 1 and 2 respectively. The lower maps in Figures 3 and 4 demonstrate the site quality rating pattern. The higher ratings, representing the better land, are darker. Ideally, there should be a very close relationship between the darker areas on the land use maps (the more demanding and productive uses) and the darker areas on the SQR maps (potentially the most productive sites).

In Leguisamo, where the vast majority of the land is presently idle, the two maps do not correlate well. This demonstrates that the optimum use is not being made of the land; many potentially productive sites are idle. An SQR of 14 is the highest rating in Leguisamo. It is located in two areas; one of which produces sugarcane, the other is idle. Many other idle sites in Leguisamo should be able to support reasonably productive farms. Notice on Figure 3 that in the north-central part of the barrio, all the land is idle with the exception of one site in the garden category. The garden is located on the site with the lowest SQR of the area; the idle sites around the garden are potentially more productive than the site that is actually under cultivation. In the northeast of Leguisamo are the two sites with the lowest SQR's of the entire study area (SQR 4 and 5). All SQR's above 5 have been found to be productive in other parts of the barrios; therefore, if the optimum land use pattern was realized, only the two sites with SQR's of 4 and 5 would be idle.

Upon examination of Figure 4, it will be noted that the situation in Ovejas is slightly more encouraging. In the northwest portion of the barrio, where the highest SQR's are found, sugarcane is produced. This represents the use of the

LEGUISAMO LAND USE CATEGORIES



LEGUISAMO SITE QUALITY RATINGS

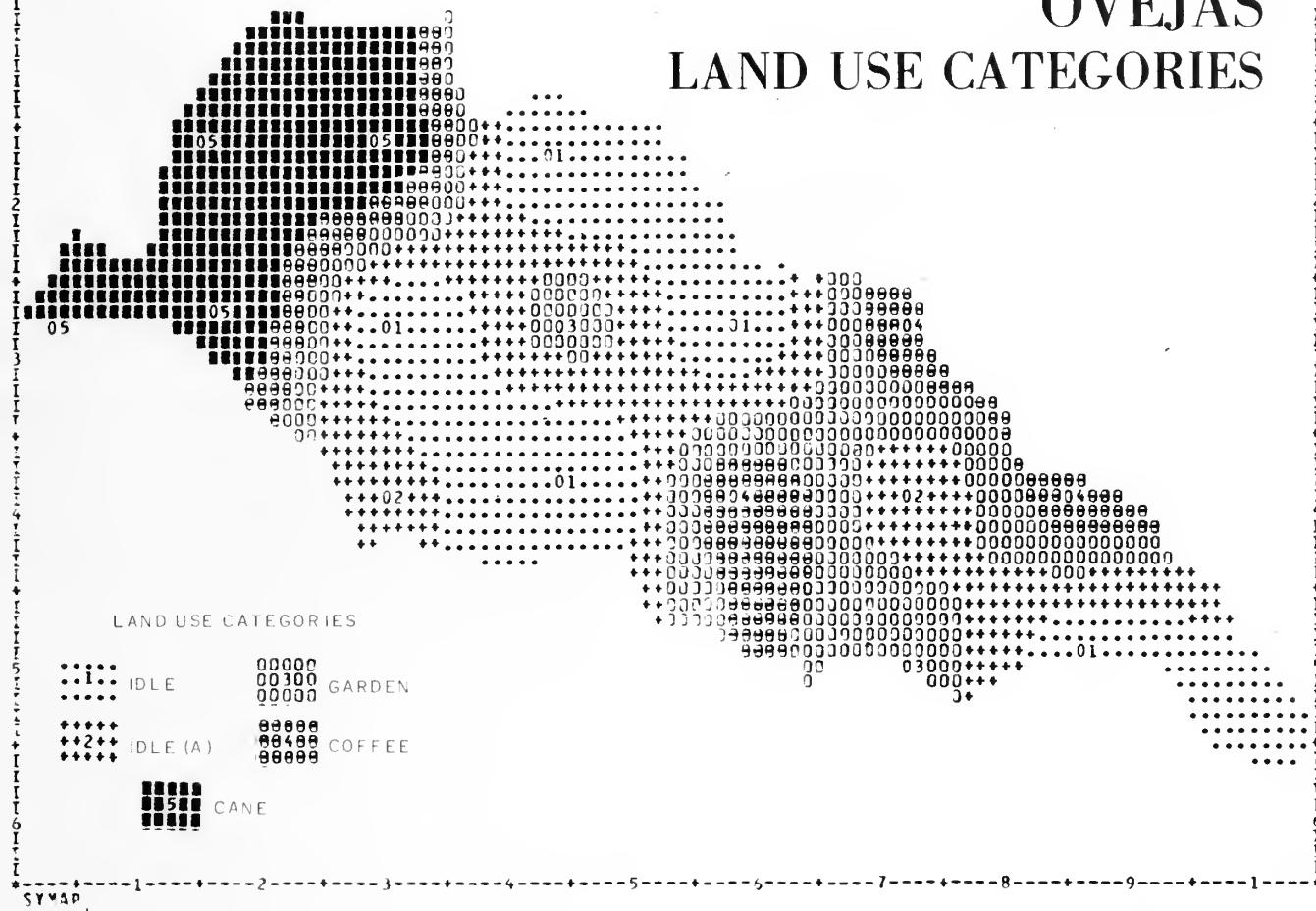


FIGURE 4

21

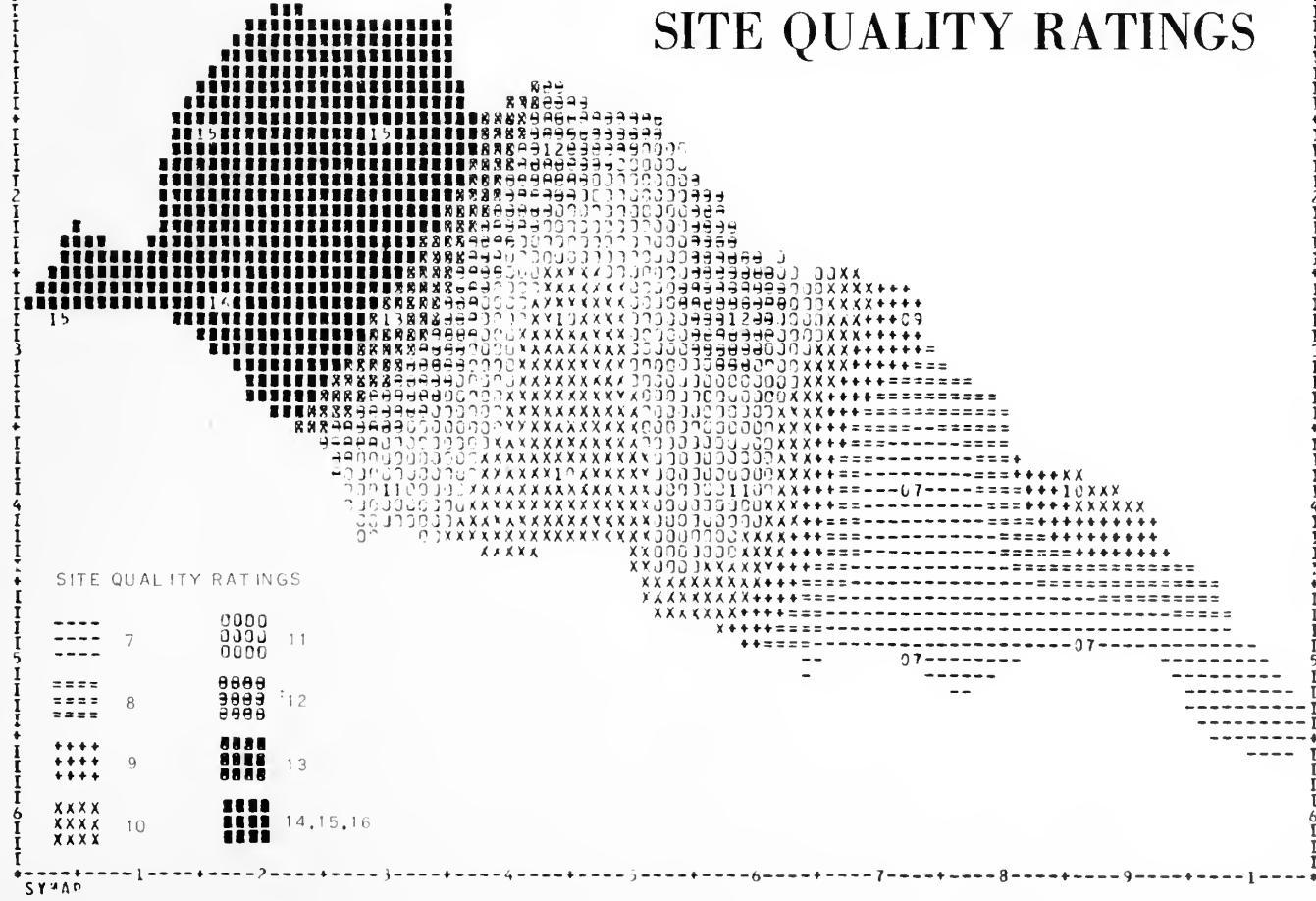
OVEJAS

LAND USE CATEGORIES



OVEJAS

SITE QUALITY RATINGS



best land for the most demanding and productive crop. However in the central area of the barrio, the maps no longer correlate well. Here, each site is capable of producing coffee (SQR 10 - 12); nevertheless all sites are idle with the exception of one in a garden. Although some coffee is produced in the southeastern portion of the barrio, potentially productive land (SQR 7) is standing idle in this area also. If the optimum land use pattern was realized in Ovejas, there would be no idle land. All in all, even though a considerable amount of land is being wasted in Ovejas (43% is idle), the correlation between observed land use and the optimum use is much higher than in Leguisamo where 86% of the land is presently idle.

CONCLUSIONS

Using the optimum ranges from Table 3 and the data from Appendix E, it can be determined that only 27% of the sites studied are currently being used in an optimum fashion. Four percent of the sites are overutilized and experiencing low productivity (such as coffee growing on a SQR 9 site). The remaining 69% are underutilized. Most of this land is idle although it should be capable of being cultivated. In a country where a good deal of the population is unemployed and most of the food consumed is imported and expensive, gross underutilization of potentially productive land is a problem that deserves a great deal of attention.

Now that it has been shown that there is a great deal of idle land and that most of the land is capable of being productive, the next step is logically to initiate a positive change. Further studies of this nature are warranted to facilitate the development of a workable plan for returning Puerto Rico's vast areas of idle land to productivity.

APPENDIX A**UNIVERSAL SOIL LOSS EQUATION****FACTORS AND COMPUTATIONS**

UNIVERSAL SOIL LOSS EQUATION
FACTORS AND COMPUTATIONS

| <u>SITE</u> | <u>R</u> | <u>K</u> | <u>L (feet)</u> | <u>S feet/%</u> | <u>A</u> |
|-------------|----------|----------|-----------------|-----------------|----------|
| 1 | 400 | .02 | 600 | 164/27 | 131.56 |
| 2 | 500 | .10 | 950 | 197/21 | 684.30 |
| 3 | 500 | .10 | 950 | 230/24 | 851.70 |
| 4 | 500 | .10 | 775 | 394/51 | 1637.00 |
| 5 | 500 | .10 | 575 | 197/34 | 1150.57 |
| 6 | 400 | .02 | 950 | 262/28 | 175.71 |
| 7 | 500 | .10 | 1050 | 312/30 | 1287.85 |
| 8 | 500 | .02 | 925 | 230/25 | 179.10 |
| 9 | 500 | .10 | 725 | 148/20 | 548.87 |
| 10 | 500 | .02 | 1200 | 164/14 | 79.50 |
| 11 | 500 | .02 | 1200 | 230/19 | 130.15 |
| 12 | 500 | .10 | 1925 | 525/27 | 1472.60 |
| 13 | 500 | .10 | 950 | 279/29 | 1161.70 |
| 14 | 500 | .10 | 700 | 394/56 | 1636.00 |
| 15 | 400 | .02 | 800 | 312/39 | 217.36 |
| 16 | 400 | .02 | 400 | 115/29 | 120.68 |
| 17 | 500 | .02 | 1275 | 344/27 | 239.78 |
| 18 | 500 | .10 | 2250 | 410/18 | 818.00 |
| 19 | 500 | .10 | 1975 | 246/12 | 400.87 |
| 20 | 500 | .02 | 1200 | 246/20 | 141.30 |
| 21 | 500 | .10 | 1200 | 246/20 | 706.50 |
| 22 | 500 | .10 | 750 | 98/13 | 280.37 |
| 23 | 500 | .02 | 900 | 344/38 | 337.64 |
| 24 | 500 | .02 | 1825 | 558/31 | 427.60 |
| 25 | 500 | .02 | 725 | 197/27 | 180.76 |
| 26 | 500 | .02 | 525 | 66/12 | 41.35 |
| 27 | 500 | .02 | 475 | 148/31 | 182.19 |
| 28 | 500 | .02 | 200 | 49/25 | 83.30 |
| 29 | 500 | .02 | 1200 | 66/ 5 | 17.05 |
| 30 | 400 | .10 | 950 | 16/ 2 | 15.80 |
| 31 | 500 | .10 | 1425 | 16/ 1 | 22.00 |
| 32 | 500 | .17 | 1200 | 115/10 | 402.90 |
| 33 | 400 | .17 | 500 | 9/ 2 | 22.40 |
| 34 | 400 | .24 | 1000 | 7/ 1 | 19.20 |
| 35 | 500 | .02 | 2325 | 230/10 | 66.10 |
| 36 | 500 | .02 | 1150 | 180/16 | 96.20 |
| 37 | 500 | .02 | 925 | 180/19 | 114.20 |
| 38 | 500 | .10 | 500 | 131/26 | 704.70 |
| 39 | 400 | .10 | 400 | 33/ 8 | 79.20 |
| 40 | 400 | .02 | 400 | 98/25 | 94.20 |
| 41 | 400 | .02 | 600 | 115/19 | 68.60 |
| 42 | 400 | .10 | 575 | 230/40 | 1157.70 |
| 43 | 500 | .10 | 825 | 82/10 | 196.50 |
| 44 | 400 | .10 | 650 | 213/33 | 852.40 |
| 45 | 500 | .10 | 1600 | 459/29 | 1507.75 |

APPENDIX B

SITE QUALITY RATING SYSTEM INDEXES

SITE QUALITY RATING SYSTEM INDEXES

Erosion Index (EI)

| <u>A Factor From USLE</u> | <u># of Sites Represented</u> | <u>Erosion Index (EI)</u> |
|-------------------------------|-----------------------------------|-------------------------------|
| 0 - 50 | 6 | 5 |
| 50 - 150 | 12 | 4 |
| 150 - 350 | 9 | 3 |
| 350 - 750 | 7 | 2 |
| 750 plus | 11 | 1 |

Slope Index (SI)

| <u>Percent Slope</u> | <u># of Sites Represented</u> | <u>Slope Index (SI)</u> |
|--------------------------|-----------------------------------|-----------------------------|
| 0 - 20 | 21 | 3 |
| 20 - 40 | 21 | 2 |
| 40 plus | 3 | 1 |

Soil Type Index (STI)

| <u>Soil Type</u> | <u># of Sites Represented</u> | <u>Soil Type Index (STI)</u> |
|----------------------|-----------------------------------|----------------------------------|
| ToA | | |
| Cn | 3 | 3 |
| DaD2 | | |
| DaE2 | | |
| HmD2 | | |
| HmE2 | 15 | 2 |
| LaD2 | | |
| Re | | |
| HmF2 | | |
| CoE | 27 | 1 |
| CoF2 | | |

SITE QUALITY RATING SYSTEM INDEXES

Chemical Fertility Indexes (CFI)

Cation Exchange Capacity Rating (CEC) --

| <u>Actual CEC meq/100g</u> | <u>Rating</u> | <u>Potassium Rate as per A&L</u> | <u>Rating</u> |
|--|---------------|--|---------------|
| 15 plus | 2 | High or | |
| 10 - 15 | 1 | Medium | 1 |
| 10 & less | 0 | Low | 0 |
| <u>Magnesium Rate as per A&L</u> | <u>Rating</u> | <u>Calcium Rate as per A&L</u> | <u>Rating</u> |
| High or | | High or | |
| Medium | 1 | Medium | 1 |
| Low | 0 | Low | 0 |
| <u>Total From Above</u> | | <u># of Sites Represented</u> | |
| 5 | | 0 | |
| 4 | | 2 | |
| 3 | | 5 | |
| 2 | | 10 | |
| 1 | | 28 | |

Estimated Nitrogen Release (ENR) --

| <u>ENR Rate as per A&L</u> | <u># of Sites Represented</u> | <u>Rating</u> |
|------------------------------------|-----------------------------------|---------------|
| High | 9 | 2 |
| Medium | 31 | 1 |
| Low | 5 | 0 |

pH Rating (pH) --

| <u>pH</u> | <u># of Sites Represented</u> | <u>Rating</u> |
|------------|-----------------------------------|---------------|
| 5.2 plus | 12 | 1 |
| 5.1 & less | 33 | 0 |

APPENDIX C

EXPLANATION OF SOIL TYPES

EXPLANATION OF SOIL TYPES

| SERIES | SOIL | CHARACTERISTICS | SITES | USES ENCOUNTERED |
|---------|------|--|--|--|
| Consumo | | Well drained, very strongly acid, moderately permeable. Found in volcanic uplands, strongly leached, clayey. | | |
| | CoE | 20 to 40% slopes | 9,18 38,42 | Idle, Coffee (2) Idle (A) |
| | CoF2 | 40 to 60% slopes | 2,3,4,5, 7,12,13, 14,19,21 22,43,44 45 | (4) Idle (6) Idle (A) (2) Garden (2) Coffee |
| Daguey | | Deep, well drained, very strongly acid, moderately permeable. Found in volcanic uplands, strongly leached, clayey | | |
| | DaD2 | 12 to 20% slopes | 11,36 | Idle, Garden |
| | DaE2 | 20 to 40% slopes | 1,37 | (2) Idle |
| Humatas | | Deep, well drained, very strongly acid, moderately permeable. Found in volcanic uplands, strongly leached, clayey. | | |
| | HmD2 | 12 to 20% slopes | 6,23,26 27,35 | (3) Idle Cane, Idle (A) |
| | HmE2 | 20 to 40% slopes | 10,40,41 | Idle (A), Other, Coffee |
| | HmF2 | 40 to 60% slopes | 8,15,16, 17,20,24 25,28,29 | (3) Idle, (5) Idle (A) (1) Coffee |

EXPLANATION OF SOIL TYPES

| SERIES | SOIL | CHARACTERISTICS | SITES | USES ENCOUNTERED |
|--------|------|--|--------|---------------------|
| Coloso | | Deep, somewhat poorly drained, slightly acid, moderately permeable. Found along river, floods frequently, form in sediment from volcanic and limestone uplands, loamy | | |
| | Cn | Nearly level | 34 | Cane |
| ToA | | Deep, moderately well drained, slightly acid, moderately permeable. Found along rivers, floods frequently, form in sediment from volcanic and limestone uplands loamy. | | |
| | ToA | Near rivers, slightly higher elevations | 32, 33 | Other Cane |
| Reilly | | Gravelly, excessively drained, rapidly permeable, adjacent to riverbanks, floods frequently. | | |
| | Re | Gravelly loam | 30, 31 | (2) Cane |
| Lares | | Deep, moderately well drained, very strongly acid, moderately permeable. Found on old terraces. | | |
| | LaD2 | 5 to 20% slopes | 39 | Idle (A) |

APPENDIX D

SOIL CONSERVATION SERVICE CAPABILITY UNITS

SOIL CONSERVATION SERVICE CAPABILITY UNITS

| SCS CAPABILITY RATING | DESCRIPTION | SOIL TYPES INCLUDED | SQR STI |
|-----------------------------|--|---------------------------|------------|
| Class I | Few limitations that restrict use. | ToA | 3 |
| Class II | Moderate limitations that reduce the choice of plants or that require special conservation practices. | Cn | 3 |
| Class III | Severe limitations that reduce the choice of plants, require special conservation practices, or both. | DaD2 HmD2 LaD2 | 2 |
| Class IV | Very severe limitations that reduce the choice of plants, require very careful management, or both. | DaE2 HmE2 Re | 2 |
| Class V | Subject to little or no erosion but have other limitations that limit use to largely pasture, woodland, or wildlife habitat. (No Class V soils in Mayaguez Area). | | |
| Class VI | Severe limitations that make soils generally unsuited for cultivation and limit use largely to pasture, woodland, or wildlife habitat. | CoE HmF2 | 1 |
| Class VII | Very severe limitations that make soils unsuited to cultivation and restrict their use largely to pasture, woodland, and wildlife habitat. | CoF2 | 1 |
| Class VIII | Limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes. (No Class VIII soils in study area). | | |

APPENDIX E

SITE QUALITY RATING SYSTEM FACTORS,
RATING, AND USE, BY SITE

SITE QUALITY RATING SYSTEM FACTORS,
RATING, AND USE, BY SITE

| <u>SITE</u> | <u>EI</u> | <u>SI</u> | <u>STI</u> | <u>CEC</u> | <u>ENR</u> | <u>pH</u> | <u>SQR</u> | <u>USE</u> |
|-------------|-----------|-----------|------------|------------|------------|-----------|------------|------------|
| 1 | 4 | 2 | 2 | 3 | 2 | 1 | 14 | Idle |
| 2 | 2 | 2 | 1 | 1 | 1 | 0 | 7 | Idle (A) |
| 3 | 1 | 2 | 1 | 1 | 1 | 0 | 6 | Garden |
| 4 | 1 | 1 | 1 | 1 | 0 | 0 | 4 | Idle (A) |
| 5 | 1 | 2 | 1 | 1 | 1 | 0 | 6 | Idle (A) |
| 6 | 3 | 2 | 2 | 2 | 1 | 1 | 11 | Idle (A) |
| 7 | 1 | 2 | 1 | 1 | 1 | 0 | 6 | Idle |
| 8 | 3 | 2 | 1 | 1 | 1 | 0 | 8 | Idle (A) |
| 9 | 2 | 2 | 1 | 1 | 2 | 0 | 8 | Idle (A) |
| 10 | 4 | 3 | 2 | 1 | 2 | 0 | 12 | Idle (A) |
| 11 | 4 | 3 | 2 | 1 | 1 | 0 | 11 | Idle |
| 12 | 1 | 2 | 1 | 1 | 1 | 0 | 6 | Idle |
| 13 | 1 | 2 | 1 | 1 | 1 | 0 | 6 | Idle (A) |
| 14 | 1 | 1 | 1 | 1 | 1 | 0 | 5 | Idle (A) |
| 15 | 3 | 2 | 1 | 1 | 1 | 0 | 8 | Idle (A) |
| 16 | 4 | 2 | 1 | 1 | 1 | 0 | 9 | Idle |
| 17 | 3 | 2 | 1 | 1 | 1 | 0 | 8 | Idle |
| 18 | 1 | 3 | 1 | 1 | 2 | 0 | 8 | Idle |
| 19 | 2 | 3 | 1 | 1 | 1 | 0 | 8 | Idle (A) |
| 20 | 4 | 2 | 1 | 2 | 1 | 0 | 10 | Idle |
| 21 | 2 | 2 | 1 | 1 | 1 | 0 | 7 | Idle |
| 22 | 3 | 3 | 1 | 1 | 1 | 0 | 9 | Coffee |
| 23 | 3 | 2 | 2 | 2 | 1 | 1 | 11 | Idle |
| 24 | 2 | 2 | 1 | 1 | 1 | 0 | 7 | Idle (A) |
| 25 | 3 | 2 | 1 | 3 | 2 | 1 | 13 | Coffee |
| 26 | 5 | 3 | 2 | 2 | 1 | 1 | 14 | Cane |
| 27 | 3 | 2 | 2 | 2 | 1 | 1 | 11 | Idle |
| 28 | 4 | 2 | 1 | 1 | 1 | 0 | 9 | Idle (A) |
| 29 | 5 | 3 | 1 | 1 | 1 | 0 | 11 | Idle (A) |
| 30 | 5 | 3 | 2 | 4 | 0 | 1 | 15 | Cane |
| 31 | 5 | 3 | 2 | 4 | 0 | 1 | 15 | Cane |
| 32 | 2 | 3 | 3 | 3 | 0 | 1 | 12 | Other |
| 33 | 5 | 3 | 3 | 3 | 0 | 1 | 15 | Cane |
| 34 | 5 | 3 | 3 | 3 | 1 | 1 | 16 | Cane |
| 35 | 4 | 3 | 2 | 1 | 2 | 1 | 13 | Idle |
| 36 | 4 | 3 | 2 | 1 | 0 | 0 | 10 | Garden |
| 37 | 4 | 3 | 2 | 1 | 2 | 0 | 12 | Idle |
| 38 | 2 | 2 | 1 | 2 | 2 | 0 | 9 | Coffee |
| 39 | 4 | 3 | 2 | 1 | 1 | 0 | 11 | Idle (A) |
| 40 | 4 | 2 | 2 | 1 | 1 | 0 | 10 | Other |
| 41 | 4 | 3 | 2 | 1 | 1 | 0 | 11 | Coffee |
| 42 | 1 | 1 | 1 | 2 | 2 | 0 | 7 | Idle (A) |
| 43 | 3 | 3 | 1 | 2 | 1 | 0 | 10 | Coffee |
| 44 | 1 | 2 | 1 | 2 | 1 | 0 | 7 | Garden |
| 45 | 1 | 2 | 1 | 2 | 1 | 0 | 7 | Idle |

APPENDIX F

EXAMPLE COMPUTATION OF A SITE QUALITY RATING

EXAMPLE COMPUTATION OF A SITE QUALITY RATING

SITE #1

Erosion Index (EI)

| | | |
|---------------------------|--------|---|
| USLE A-Value (Appendix A) | 131.56 | |
| EI | | 4 |

Slope Index (SI)

| | | |
|----------------------------|----|---|
| Percent Slope (Appendix A) | 27 | |
| SI | | 2 |

Soil Type Index (STI)

| | | |
|------------------------|------|---|
| Soil Type (Appendix C) | DaE2 | |
| STI | | 2 |

Chemical Fertility Index (CFI)

(as per A&L Great Lakes Agricultural Laboratories)

| | | |
|-----------------------------------|--------|-----|
| Cation Exchange Capacity Rating | | |
| Actual CEC | 7.1 | (0) |
| Potassium | High | (1) |
| Magnesium | Medium | (1) |
| Calcium | Medium | (1) |
| TOTAL CEC RATING | | 3 |
| Estimated Nitrogen Release Rating | High | 2 |
| pH Rating | 5.7 | 1 |

SITE QUALITY RATING

14

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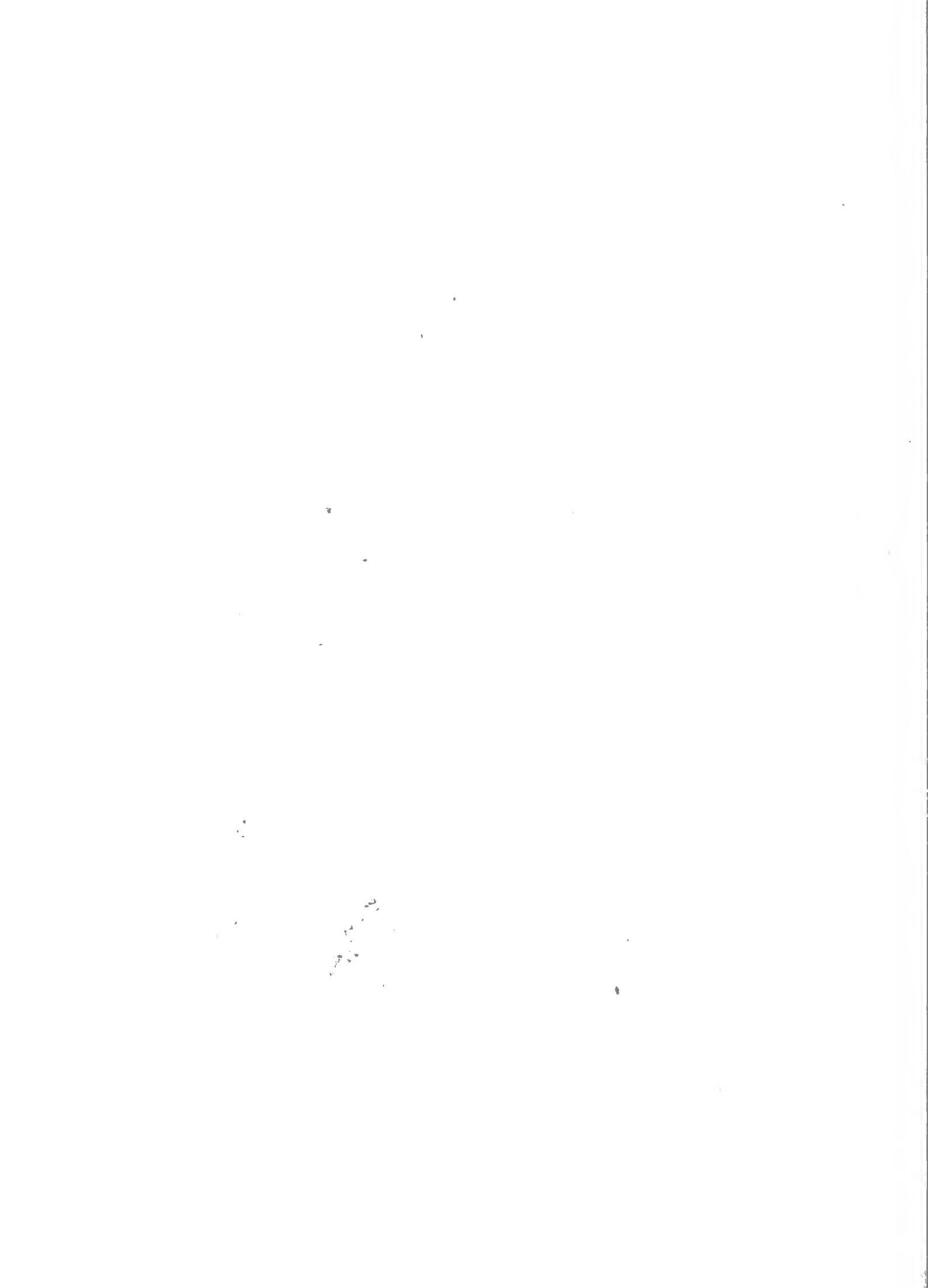
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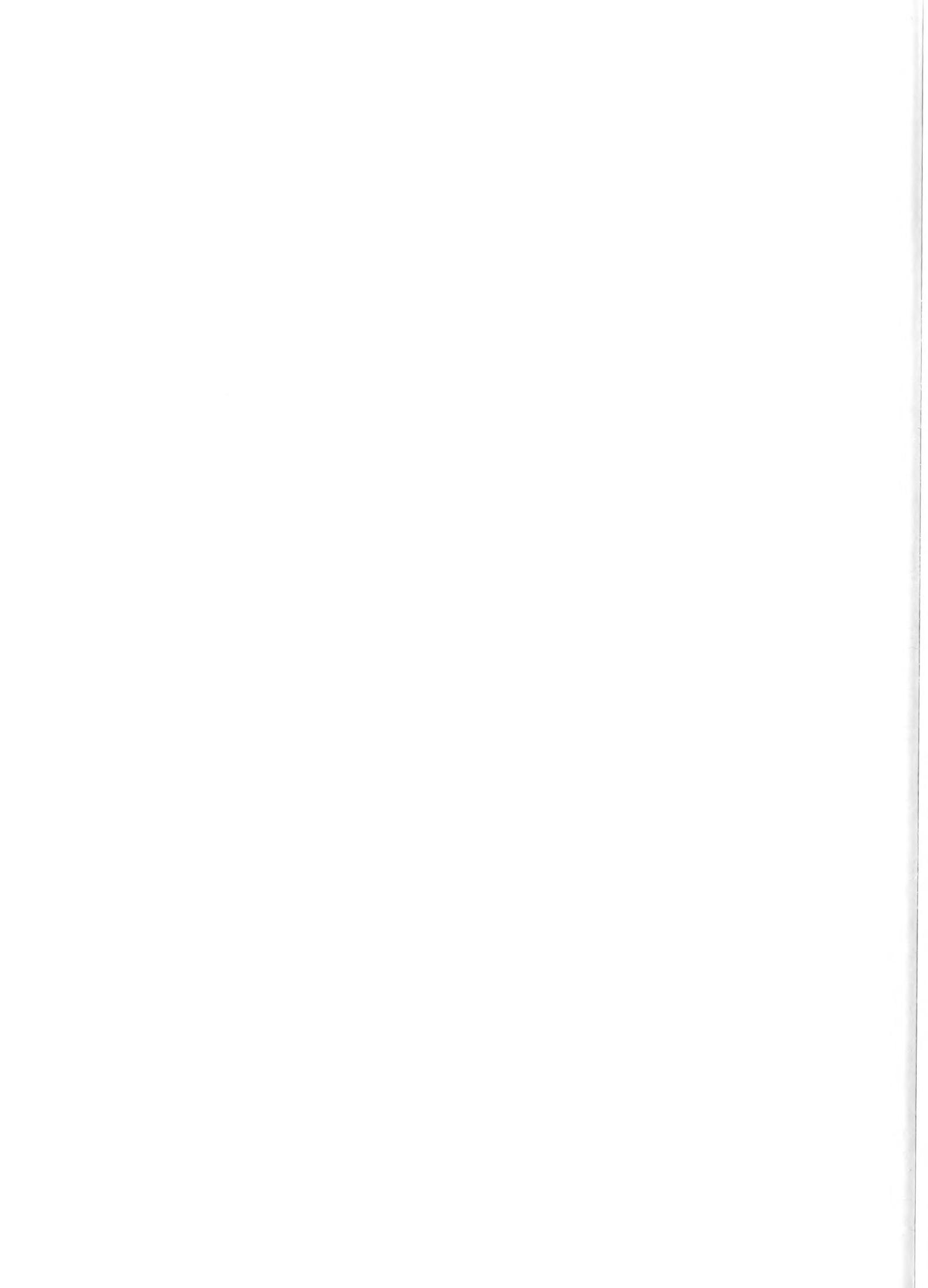
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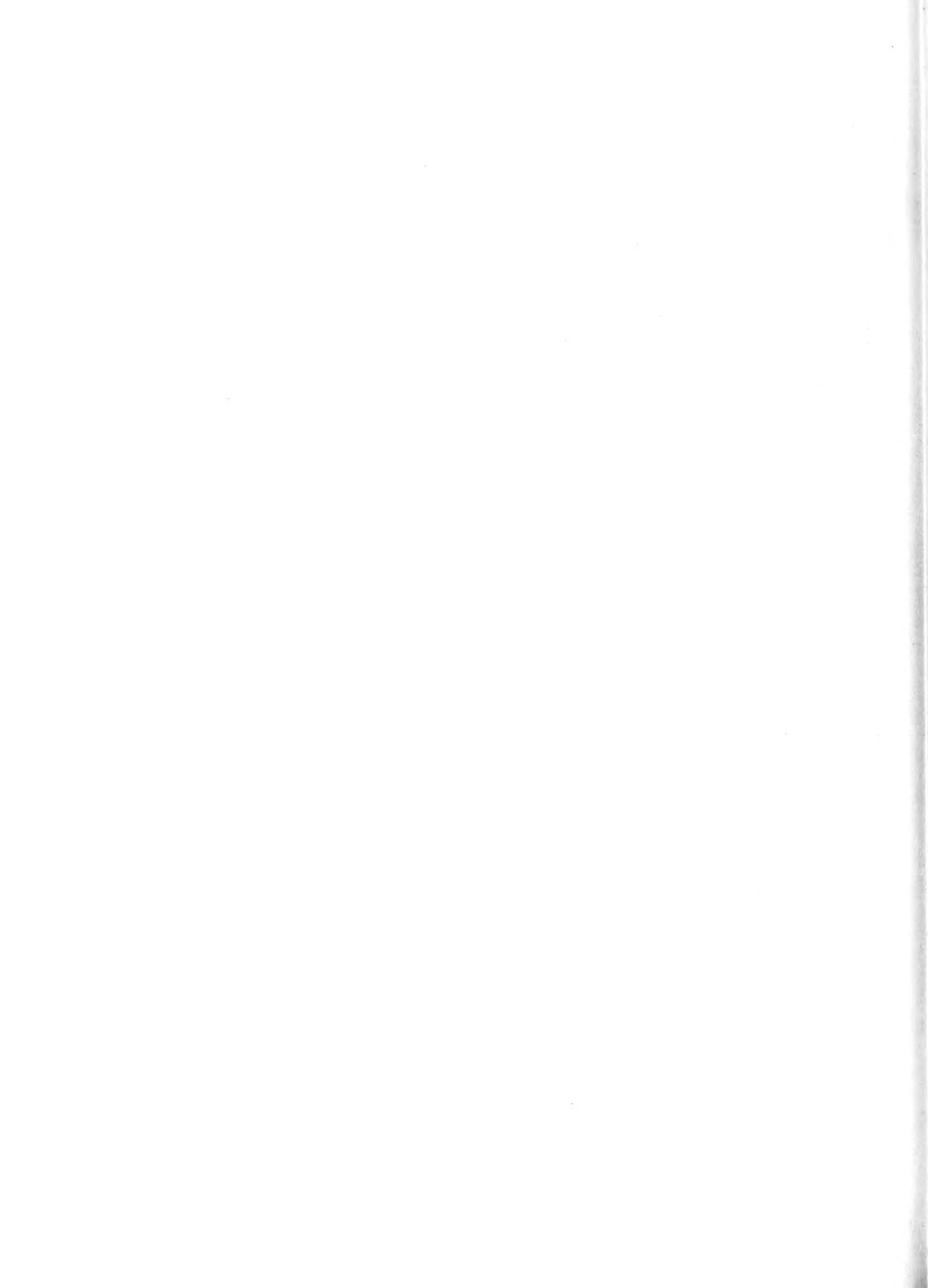
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